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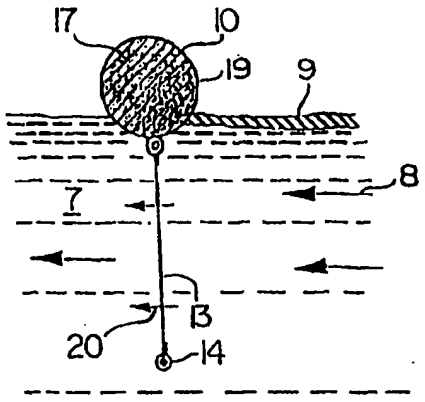
(54) Title: FLOW THROUGH SPILL COLLECTION BOOM



(57) Abstract

An improved boom for use in containing oil spills and the like on water comprises a flotation tube, an upper chain pocket, a skirt, and a lower chain pocket. The boom is strengthened by placing a chain, or wire rope if a stiff boom is required, in the upper chain pocket. The skirt is made to sink by placing a chain in the lower chain pocket. Both the tube, pockets, and skirt are fabricated from a plastic mesh pervious to both water and the spill. The spill is contained, and buoyancy provided for the boom, by filling the flotation tube with a particulate liquid sorbent, which preferably is a particulate polyurethane material. This boom has significant advantages when used on flowing water, as the water can pass through the boom without having to flow under it and thereby entrain some of the spill with it. A smaller pillow boom, which has no skirt or lower chain pocket, and which is of use in containing small localised spills is constructed in the same way.

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FLOW THROUGH SPILL COLLECTION BOOM.

This invention relates to spill booms, of the type used to contain, and to recover, a lighter liquid existing as a relatively thin layer upon a heavier liquid with which it is essentially immiscible. By far the most common occurrence for which booms of this type are used is to contain and recover an immiscible light liquid existing as a relatively thin film on water. Thus such a boom is commonly used in dealing with oil, and other liquid chemical, spills on both fresh and sea water.

The commonly used boom comprises essentially a flotation element, a skirt element, a reinforcing element, and a sinker. In use, the skirt depends from the flotation downwardly into the water, and is weighted by the sinker. Lateral forces - which can be quite substantial, are accommodated by the reinforcement. Generally, both the sinker and the reinforcement are chains of suitable strength and weight. Both the flotation and the skirt are commonly constructed from a plastics material which is both reasonably flexible, and impervious to the liquid being contained or recovered.

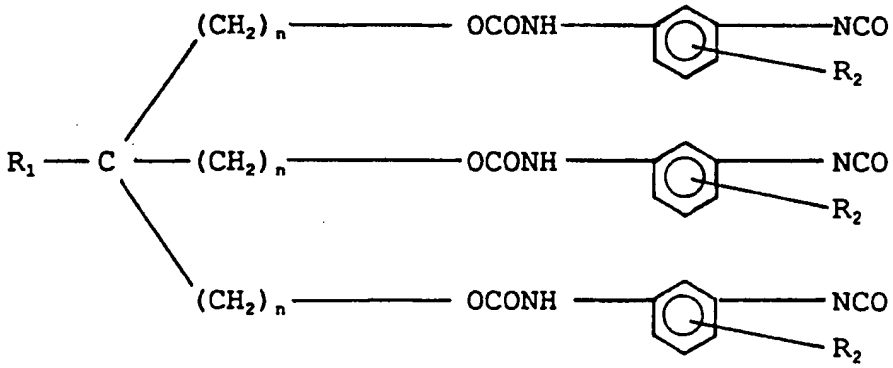
Whilst booms of this general type are effective, and indeed are often used in dealing with oil spills, they are not wholly satisfactory, and have certain disadvantages. In particular, they are not completely effective in containing a spill on water which is moving, either continuously, such as in a river or in a seaway, or discontinuously, such as in tidal water. In such situations the overall water flow past the boom poses a problem: the boom itself is essentially impervious and serves to obstruct the water flow. And yet the flow cannot be stopped. Consequently, water flows under the boom skirt, and carries entrained spilt material with it. Hence, these booms are most effective when used in still water - which in fact is a very rare occurrence. It therefore follows that when such a boom is used in moving water, for example to contain a liquid spill from a surface sewer or drain into a river, its effectiveness leaves something to be desired.

This invention seeks to overcome these shortcomings of these known booms, by providing a boom system through which water can flow with but little hindrance, and though which a spilt liquid, such as oil, substantially cannot flow. Thus, this invention seeks to provide a spill collection boom system that is pervious to the heavier liquid, and substantially impervious to the lighter liquid.

Thus, in its broadest embodiment, this invention provides a boom system for containing a lighter liquid disposed on top of a heavier liquid with which it is substantially immiscible comprising a flotation element, a reinforcing element, a skirt element, and a sinker, wherein the flotation element comprises a mesh pervious to both the lighter and the heavier liquid, and the skirt element comprises a mesh pervious to at least the heavier liquid, and wherein the flotation element is filled with a particulate liquid sorbent adapted to absorb the lighter liquid, and to provide sufficient flotation for the boom.

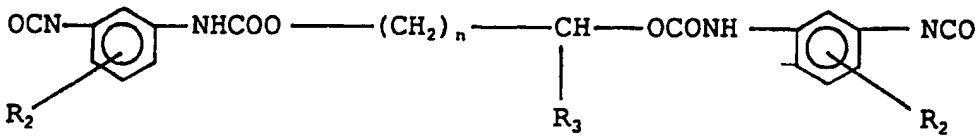
Preferably, the particulate solid liquid sorbent is readily separable from the absorbed liquid, and reusable. Most preferably, the solid sorbent comprises a particulate polyurethane liquid sorbent prepared by a process comprising :

(i) reacting together at a temperature of from 180° to 200°, for a time of less than 10 minutes, a prepolymer of the formula A:



A

with a prepolymer of the general formula B:



B

in the presence of a lower alkyl ester of the general formula C:

$$R_1COOR_4 \qquad C$$

in which: n represents 1, 2, or 3;

R_1 represents a lower alkyl group having 1 to 6 carbon atoms;

R_2 represents hydrogen or a lower alkyl group having 1 to 4 carbon atoms; and

R_3 and R_4 represent a lower alkyl group having 1 to 3 carbon atoms,

and when R_2 is other than hydrogen, it is in the meta or para position relative to the -NH- linkage;

and wherein the weight ratio of prepolymer of formula A to prepolymer of formula B is about 3:1, and the reaction mixture contains from 22% to 25% by weight of ester solvent;

(ii) cooling the thus formed polymer;

(iii) adding thereto an alcoholic medium chosen from the group consisting of:

(a) ethanol; or

(b) a mixture of ethanol, methanol, and water containing 85% by weight ethanol, up to 15% by weight methanol, remainder to 100% water, or

(c) ethanol containing from 4% to 6% by weight isopropanol;

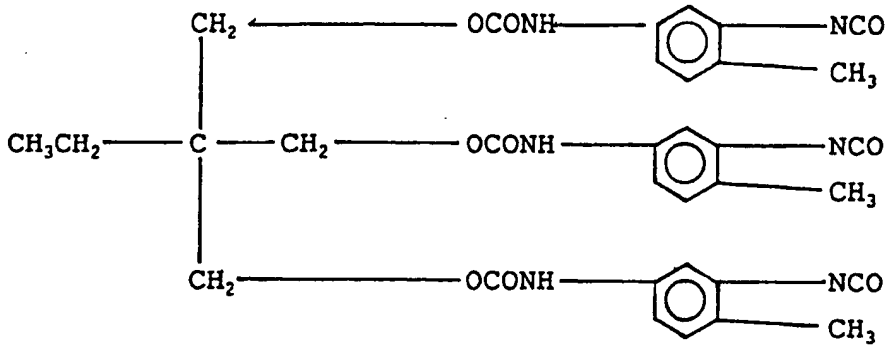
(iv) adding thereto with mixing hexamethylene tetramine,

(v) allowing the spontaneous reaction to proceed thereafter during which a temperature in the range of 55° to 65° is developed, and during which at least some of both the lower alkyl ester solvent, the alcoholic medium, and any water present, evaporate and

(vi) recovering the particulate polyurethane product.

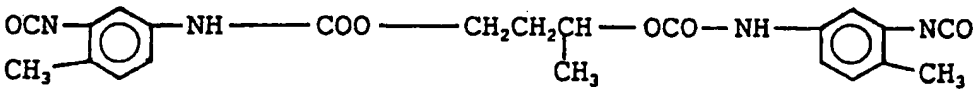
Preferably, microspheres comprising an aluminosilcate shell containing gas, having a diameter of from 10 um to 100 um are added to the reaction mixture between steps (iii) and (iv).

Preferably, (i) the prepolymer has the formula A_1:



A_1

(ii) the prepolymer B has the formula B_1



B1

and (iii) the lower alkyl ester solvent is ethyl acetate, and the alcoholic medium is ethanol.

These particulate liquid sorbents are more particularly described in Canadian Application 2,085,951. Hereafter, they will be referred to as RPA.

The invention will now be described by way of reference to the drawings in which:

Figure 1 shows a prior art boom;
Figure 2 shows a cross section of the boom of Figure 1;
Figure 3 shows a boom according to the invention;
Figure 4 shows a cross section of the boom of Figure 3;
Figures 5 and 6 show a connector for the boom of Figure 3;
Figure 7 shows and end of the boom of Figure 3;
Figure 8 shows two boom ends connected together;
Figure 9 shows an alternative boom construction; and

Figure 10 shows a catchment boom in use in a flow situation.

These Figures will be described for simplicity in the context of a spill of an immiscible liquid, typically oil, on water. However it is to be understood that this invention is not so limited and can be used for the containment and recovery of a light liquid spread on the surface of a heavier one, with which it is essentially immiscible.

In Figure 1 is shown diagrammatically the known type of boom which this invention seeks to improve. The boom comprises a flotation tube 1 from which depend downwardly in sequence an upper chain pocket 2 containing a chain 3, a skirt 4, and a lower chain pocket 5 containing a chain 6. The chains 3 and 6 are linked together when the boom sections, which are generally about 8 meters (25 feet) long, are assembled to provide a suitable length of boom. If a stiff boom is desired, the upper chain can be replaced by a wire rope. The boom is generally constructed of a relatively durable, flexible, and chemically resistant plastic material: a common choice is sheet PVC. The flotation tube is generally about 25 to 40 cm (9 to 16 ins.) in diameter, and the skirt is about 60 cm (2 feet) deep.

Whilst this boom is used extensively it does have several drawbacks. A major one occurs when the water in which it is being used is moving. This situation is shown in Figure 2. The difficulty is that although the boom flotation tube 1 and skirt 4 will serve to contain the oil slick 9 on the water 7, the movement of the water cannot be stopped. Therefore, as shown by the arrows 8, the water will continue to flow past the boom, which functions, to a degree, as an underflow weir. The result is that as water flows under the lower chain pocket 6 at least some of the oil 9 is entrained with it. Just how much oil is entrained depends on the nature of the oil, and the water flow rate. This problem is particularly important when a catchment boom as shown in Figure 9 is in use.

Although the boom of Figures 3 and 4 is visually similar to that of Figure 1 its construction is quite different. The boom consists of a similar top flotation tube 10, from which depend downwardly in sequence an upper chain pocket 11 containing a chain or wire rope 12, a skirt 13, and a lower chain pocket 14 containing a chain 15. The skirt, and preferably also the chain pockets, are fabricated from a pervious fabric or mesh material, through which at least water will flow relatively readily. The flotation tube is fabricated from a pervious fabric or mesh material through which oil will pass, or through which both oil and water will pass. It is convenient to fabricate the flotation tube, chain pockets, and skirt from the same material. Therefore, on its own the boom will neither float nor retain an oil slick. Both flotation and oil slick retention are achieved by filling the flotation tube with particulate RPA both of a suitable size, and in a suitable quantity. As is shown in Figure 4 the RPA 17 can be packed directly into the tube 10. In practice this is not very convenient, as it makes the boom sections difficult to transport, and to assemble into a long boom. The arrangement shown in Figure 3 is therefore preferred, in which the RPA 17 is packed into a fabric or mesh inner tube 16 through which oil will flow. It is convenient to make the inner tube from the same material as is used for the rest of the boom. With this construction, it is easy to transport the boom as essentially three parts (RPA powder in bulk, the inner tube, and the boom proper) and assemble it on site.

As can be seen in Figure 4 this boom functions differently to that of Figure 1. Due to the fact that the skirt 13 is a fabric or mesh, the water flow 8 will largely pass straight through it, as at 20, with effectively no entrainment of the oil slick 9 occurring. The oil slick 9 is contained by the RPA 17 in the flotation tube 10, which it will penetrate to some extent, as shown at 19. For reasons that are unknown, it appears that even with extended exposure, the oil does not penetrate through to the outer side of the boom, and does not leak through it.

The material from which the boom and the inner tube are constructed is a fabric or mesh. A suitable fabric is a fabric woven from thermoplastic monofilaments, and which has been heatset to weld the moncfilaments to each other at substantially all the crossover points in the weave pattern. A suitable fabric is one in which the monofilaments comprise a core of polyethylene terephthalate (PET) coated with polyvinyl chloride (PVC). On heatsetting, the monofilaments become welded to each other thus transforming a woven fabric into what is effectively a sheet of mesh. Other suitable thermoplastic monofilaments from which the fabric can be made include polypropylene and other polyesters with a suitable chemically resistant coating. In such two part monofilaments, the polyester provides the desired strength, and the coating the required chemical stability.

Conveniently all of the parts of the boom are constructed of the same fabric. Alternatively, the inner tube 16 is constructed from a fabric with a different, usually finer, weave pattern to that used for the remainder of the boom.

For the currently commercially available form of RPA it has been found that a mesh with a substantially oblong hole, rather than a substantially square hole, is preferable. Such a fabric appears to have two advantages: it provides adequate powder retention, and has a less restrictive effect on the water flowing through it. A fabric having a mesh count of about 4.7 monofilaments/cm (12 monofilaments/inch) in one direction, and about 6.7 monofilaments/cm (17 monofilaments/inch) in the other, woven from monofilaments having a diameter of about 0.64 mm (0.025 inch) has been found to be satisfactory. A nonwoven sheet fabric with suitably sized and placed apertures could also be used. If the fabric mesh is too small, no oil penetrates into the RPA in the flotation tube, and water flow through the boom is unduly restricted, to the point, in the end, that the advantages of the pervious features of the boom are either impaired or lost altogether. If the fabric mesh used to contain the RPA is too

large, it is not retained in the boom, which in the end can result in the boom sinking.

In Figures 5 and 6 is shown a suitable connector device, used in joining boom sections together. As was noted above for the known booms, the boom of this invention is conveniently constructed in sections, generally 8 meters (25 feet) or 16 meters (50 feet) in length, although other section lengths can be used. In order to prevent oil spill leakage between the boom sections, a substantially oil tight joint is desirable. The connector shown is used to join together the skirt part of the boom. The connector comprises a top plate 22 to the edges of which are attached two skirt elements 23 and 24, as can be seen in Figure 6, which is a bottom view of Figures 5 and 6. The two skirt elements 23 and 24 have a curved shape, as can be seen in the bottom view of Figure 5 shown in Figure 6. The connector conveniently also carries a ring 28 on the top plate. The gap X between the skirt elements is chosen to allow the skirt to enter the connector, as will be discussed below. A convenient construction material for the connector is an aluminum alloy.

In Figure 7 is shown the end of a boom section, prepared for attachment to the connector of Figure 5. The end of the flotation tube 10 is flattened to provide an tab end portion 18 which extends a little beyond the chain pocket 11. This tab end is conveniently made by folding a portion of the flotation tube back onto itself. A plurality of holes as at 27 are also provided in the tab end. Below the flotation tube, the end 29 of the chain, or wire in a stiff boom, extends from the chain pocket. The end of the skirt 13 extends below the tab end 18 and includes a pocket 25 into which is inserted an engagement rib 26. The rib can be anything that is suitably durable and suitably stiff. The pocket is sized to be a relatively close fit to the rib.The rib can be a wooden or metal strip. Preferably, it is a plastics fibre rope;a very suitable rib material is a length of 2.5 cm nylon rope.

In Figure 8 two boom ends are shown connected together.To connect two boom section ends the connector is slid downwardly over the end of the skirt so that each rib 25 is engaged into the connector, in the spaces A in Figure 6. The gap X between the edges of the connector skirt elements whilst sufficient to allow the skirt to enter the connector, is too narrow to allow the rib 25 to pass through it, thus connecting the two skirt ends together. The two chain ends 29 extending from the two upper chain pockets are attached to the ring 28 with suitable chain shackles. The two chain ends 30 extending from the lower chain pockets are joined directly together with suitable chain shackles. The two flotation tube tab ends 18 are also pulled together, again with suitable shackles, through the holes 27 tightly, preferably so that there is a small overlap as is shown in Figure 8. In this way a strong and relatively leak proof joint is made between the boom section ends.

In Figure 9 is shown an alternative boom according to this invention. The boom shown in Figures 3 and 4 would be used to contain a significant spill. Although it could be used to deal with a small localised spill, to do so is both not very practical and would be time consuming. For a small localised spill time is often very important: fast response can prevent a small spill from becoming a problem. In order to contain such a spill a smaller boom element, often referred to as a pillow is used. The concepts of this invention can be utilised in pillows, as is shown in Figure 9. In this case the boom comprises essentially only the upper parts: the skirt element and its attached sinker are omitted. The pillow shown has a flotation element 34, which is fabricated from the same sort of mesh material, and is filled with RPA 35. On its lower side a chain pocket 37 is provided, together with a chain 38. In this case the chain acts more as a sinker than as a means to join pillows together. The chain weight is also chosen to place the pillow somewhat more deeply into the water, so that the waterline will be about the line of the major axis of the generally elliptical

shape of the pillow. Again, the spilled material 9 enters the pillow and is sorbed by the RPA, as at 36.
As is the case with the larger boom element, in the absence of the particulate sorbent 35 the pillow will neither float, nor contain the spill, as it is fabricated from mesh. As shown in Figure 9 the RPA is contained directly within the pillow; it can also be contained within an inner tube as is shown in Figure 3.

In Figure 10 a particularly advantageous use of a boom according to the invention is shown. A moving body of water 7 travelling in the direction 8 is carrying along with it an oil slick 9 between banks 32. A boom 31 is placed across the channel, to catch and to contain for removal the oil slick 9. If the boom 31 is a conventional prior art boom then it can only be successful if the water flow rate is not so high that significant entrainment of oil in the water flowing under the boom does not occur, and if the oil can be removed from in front of the boom as fast as it accumulates. As is disclosed in Canadian 2,085,951, oil removal from in front of the boom can be facilitated by positioning a continuously replenished layer of RPA, as at 33. adjacent to and in front of the boom. Nevertheless, there is significant risk that some of the oil will be entrained beneath the boom and escape. But if a boom according to this invention is used, preferably also with the same layer of RPA adjacent to and ahead of it, because the water can now flow through the boom, the entrainment risk is substantially eliminated.

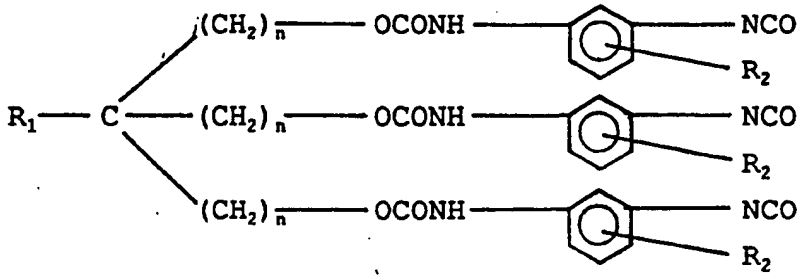
When a boom according to this invention is dismantled, any oil absorbed into the RPA in the flotation tube is recovered by a simple centrifugation step, as is more particularly described in Canadian 2,085,951.

I CLAIM:

1. A boom system for containing a lighter liquid disposed on top of a heavier liquid with which it is substantially immiscible comprising a flotation element, a reinforcing element, a skirt element, and a sinker, wherein the flotation element comprises a mesh pervious to both the lighter and the heavier liquid, and the skirt element comprises a mesh pervious to at least the heavier liquid, and wherein the flotation element is filled with a particulate liquid sorbent adapted to absorb the lighter liquid, and to provide sufficient flotation for the boom.

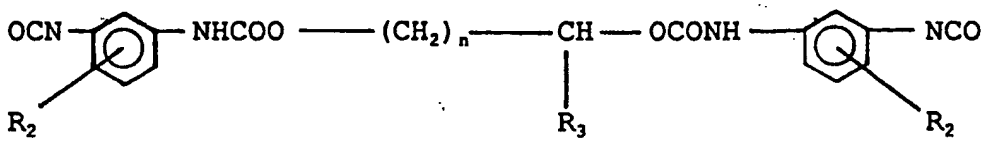
2. A boom system according to Claim 1 wherein the particulate liquid sorbent comprises a particulate polyurethane liquid sorbent prepared by a process comprising :

(i) reacting together at a temperature of from 180° to 200°, for a time of less than 10 minutes, a prepolymer of the formula A:



A

with a prepolymer of the general formula B:



B

in the presence of a lower alkyl ester of the general formula C:

R_1COOR_4 C

in which: n represents 1, 2, or 3;

R_1 represents a lower alkyl group having 1 to 6 carbon atoms;

R_2 represents hydrogen or a lower alkyl group having 1 to 4 carbon atoms; and

R_3 and R_4 represent a lower alkyl group having 1 to 3 carbon atoms,

and when R_2 is other than hydrogen, it is in the meta or para position relative to the -NH- linkage;

and wherein the weight ratio of prepolymer of formula A to prepolymer of formula B is about 3:1, and the reaction mixture contains from 22% to 25% by weight of ester solvent;

(ii) cooling the thus formed polymer;

(iii) adding thereto an alcoholic medium chosen from the group consisting of:

(a) ethanol; or

(b) a mixture of ethanol, methanol, and water containing 85% by weight ethanol, up to 15% by weight methanol, remainder to 100% water, or

(c) ethanol containing from 4% to 6% by weight isopropanol;

(iv) adding thereto with mixing hexamethylene tetramine,

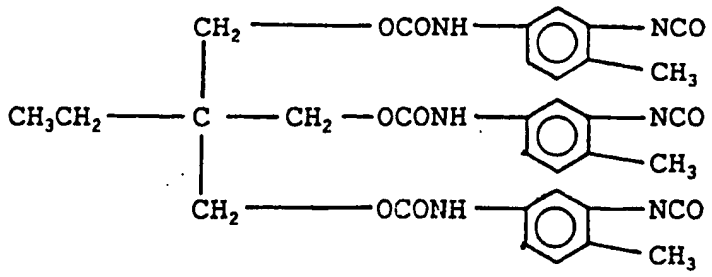
(v) allowing the spontaneous reaction to proceed thereafter during which a temperature in the range of 55° to 65° is developed, and during which at least some of both the lower alkyl ester solvent, the alcoholic medium, and any water present, evaporate and

(vi) recovering the particulate polyurethane product.

3. A boom according to Claim 2 wherein microspheres, consisting of aluminosilcate shells containing gas having a diameter of from 10 um to 100 um are added to the reaction mixture between steps (iii) and (iv).

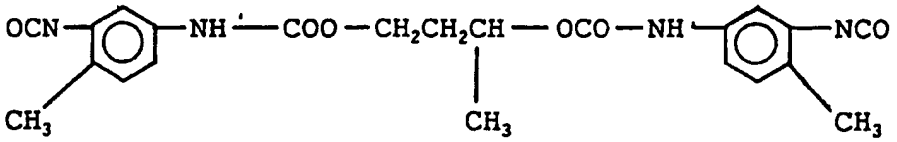
4. A boom according to Claim 2 wherein:

(i) the prepolymer has the formula A_1:



A_1

(ii) the prepolymer B has the formula B_1; and



B_1

(iii) the lower alkyl ester solvent is ethyl acetate, and the alcoholic medium is ethanol.

5. A boom according to Claim 1 wherein the upper reinforcing element comprises a chain or wire rope contained in a chain pocket in the upper edge of the skirt element adjacent the flotation element.

6. A boom according to Claim 5 wherein the upper reinforcing element comprises a chain contained in a chain pocket in the upper edge of the skirt element adjacent the flotation element.

7. A boom according to Claim 1 wherein the sinker element comprises a chain contained in a chain pocket in the lower edge of the skirt element.

8. A boom according to Claim 1 wherein the particulate liquid sorbent is contained directly within the flotation element.

9. A boom according to Claim 1 wherein the particulate liquid sorbent is contained within an inner tube, located within the flotation element, comprising a mesh pervious to at least the lighter liquid.

10. A boom according to Claim 9 wherein the inner tube mesh is pervious to both the lighter and the heavier liquid.

11. A boom according to Claim 1 wherein the flotation element and the skirt element are fabricated from the same mesh, pervious to both the heavier and the lighter liquid.

12. A boom according to claim 1 wherein the reinforcing element comprises a chain or wire rope contained in a chain pocket in the upper edge of the skirt element adjacent the flotation element; the sinker element comprises a chain contained in a chain pocket in the lower edge of the skirt element; and all of the flotation element, the upper and lower chain pockets, and the skirt element consist of the same mesh material.

13. A boom according to Claim 9 wherein the flotation element and the inner tube consist of different mesh materials.

14. A boom according to Claim 9 wherein the flotation element and the inner tube consist of the same mesh material.

15. A boom according to Claim 1 wherein the mesh comprises a woven or a nonwoven fabric.

16. A boom according to Claim 15 wherein the mesh comprises a fabric woven from thermoplastic monofilaments, and which has been heatset to weld the monofilaments to each other at substantially all the crossover points in the weave pattern.

17. A boom according to Claim 16 wherein the fabric weave pattern provides substantially square holes in the fabric.

18. A boom according to Claim 16 wherein the fabric weave pattern provides substantially rectangular holes in the fabric.

19. A boom according to Claim 16 wherein the thermoplastic monofilaments comprise a core of polyester coated with polyvinylchloride.

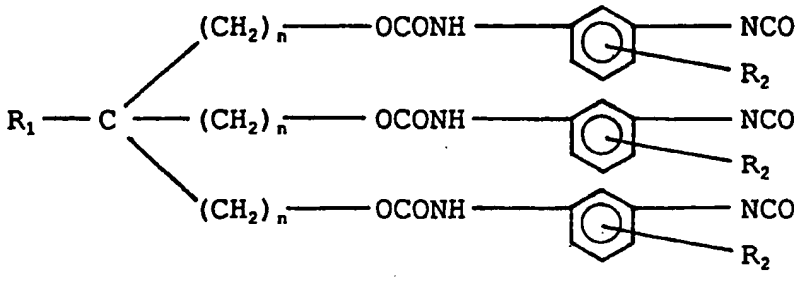
20. A boom according to Claim 19 wherein the polyester is polyethylene terephthalate.

21. A boom according to Claim 1 comprising a plurality of boom sections joined together at their ends.

22. A pillow boom for containing a lighter liquid disposed on top of a heavier liquid with which it is substantially immiscible comprising a flotation element and a sinker element, wherein the flotation element comprises a mesh pervious to both the lighter and the heavier liquid, and wherein the flotation element is filled with a particulate liquid sorbent adapted to absorb the lighter liquid, and to provide sufficient flotation for the pillow.

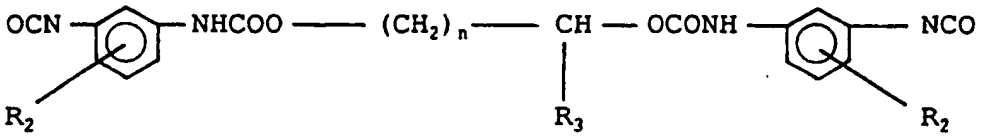
23. A pillow according to Claim 22 wherein the particulate liquid sorbent comprises a particulate polyurethane liquid sorbent prepared by a process comprising :

(i) reacting together at a temperature of from 180° to 200°, for a time of less than 10 minutes, a prepolymer of the formula A:



A

with a prepolymer of the general formula B:



B

in the presence of a lower alkyl ester of the general formula C:

$$R_1COOR_4 \qquad C$$

in which: n represents 1, 2, or 3;

R_1 represents a lower alkyl group having 1 to 6 carbon atoms;

R_2 represents hydrogen or a lower alkyl group having 1 to 4 carbon atoms; and

R_3 and R_4 represent a lower alkyl group having 1 to 3 carbon atoms,

and when R_2 is other than hydrogen, it is in the meta or para position relative to the -NH- linkage;

and wherein the weight ratio of prepolymer of formula A to prepolymer of formula B is about 3:1, and the reaction mixture contains from 22% to 25% by weight of ester solvent;

(ii) cooling the thus formed polymer;

(iii) adding thereto an alcoholic medium chosen from the group consisting of:

(a) ethanol; or

(b) a mixture of ethanol, methanol, and water containing 85% by weight ethanol, up to 15% by weight methanol, remainder to 100% water, or

(c) ethanol containing from 4% to 6% by weight isopropanol;

(iv) adding thereto with mixing hexamethylene tetramine,

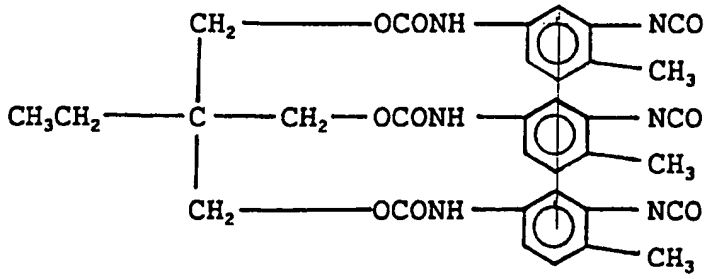
(v) allowing the spontaneous reaction to proceed thereafter during which a temperature in the range of 55° to 65° is developed, and during which at least some of both the lower alkyl ester solvent, the alcoholic medium, and any water present, evaporate and

(vi) recovering the particulate polyurethane product.

24. A pillow according to Claim 23 wherein microspheres, consisting of aluminosilcate shells containing gas having a diameter of from 10 um to 100 um are added to the reaction mixture between steps (iii) and (iv).

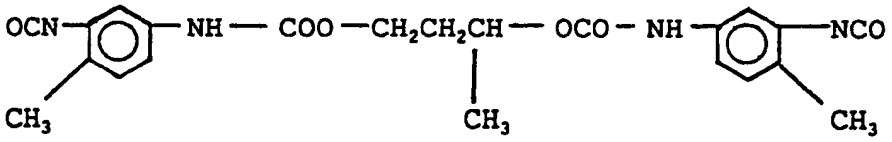
25. A pillow according to Claim 23 wherein:

(i) the prepolymer has the formula A_1:



A_1

(ii) the prepolymer B has the formula B_1:



B_1

and (iii) the lower alkyl ester solvent is ethyl acetate, and the alcoholic medium is ethanol.

26. A pillow according to Claim 22 wherein the particulate liquid sorbent is contained directly within the flotation element.

27. A pillow according to Claim 22 wherein the particulate liquid sorbent is contained within an inner tube, located within the flotation element, comprising a mesh pervious to at least the lighter liquid.

28. A pillow according to Claim 22 wherein the mesh comprises a woven or a nonwoven fabric.

29. A pillow according to Claim 28 wherein the mesh comprises a fabric woven from thermoplastic monofilaments, and which has been heatset to weld the monofilaments to each other at substantially all the crossover points in the weave pattern.

30. A pillow according to Claim 29 wherein the fabric weave pattern provides substantially square holes in the fabric.

31. A pillow according to Claim 29 wherein the fabric weave pattern provides substantially rectangular holes in the fabric.

32. A pillow according to Claim 29 wherein the thermoplastic monofilaments comprise a core of polyester coated with polyvinylchloride.

33. A pillow according to Claim 32 wherein the polyester is polyethylene terephthalate.

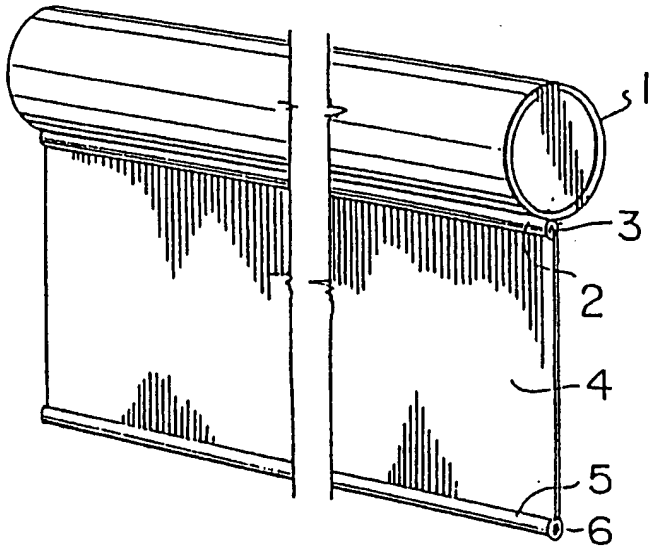


FIG.1 (PRIOR ART)

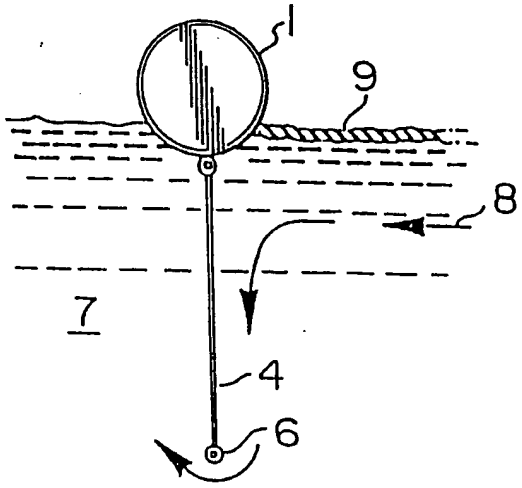


FIG.2
(PRIOR ART)

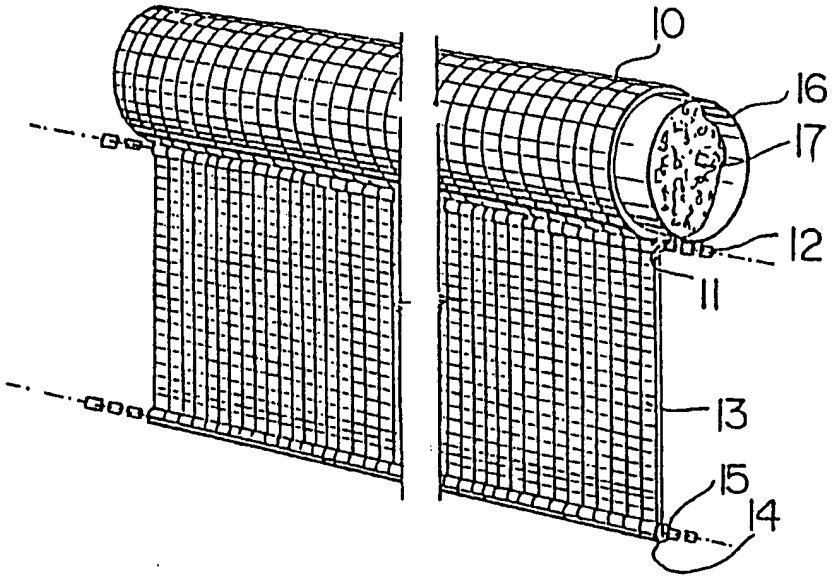


FIG.3

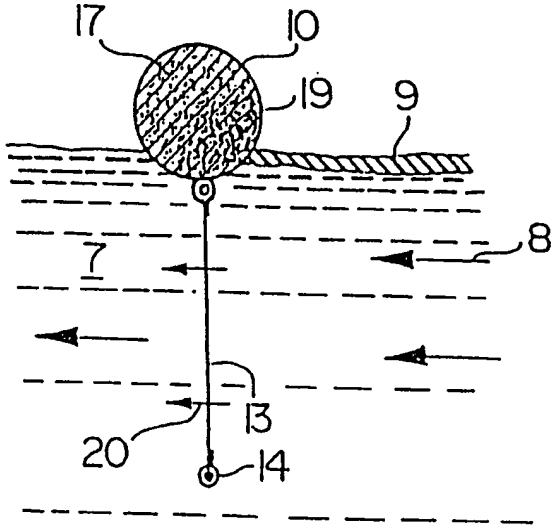


FIG.4

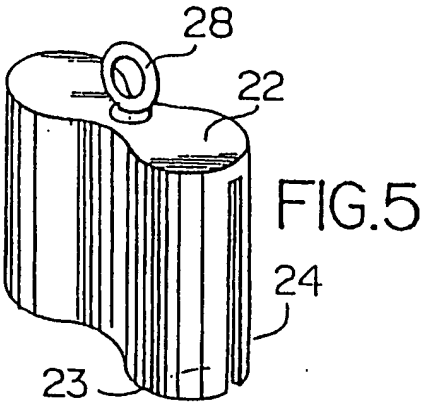


FIG.5

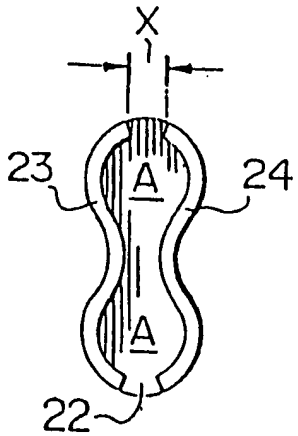


FIG.6

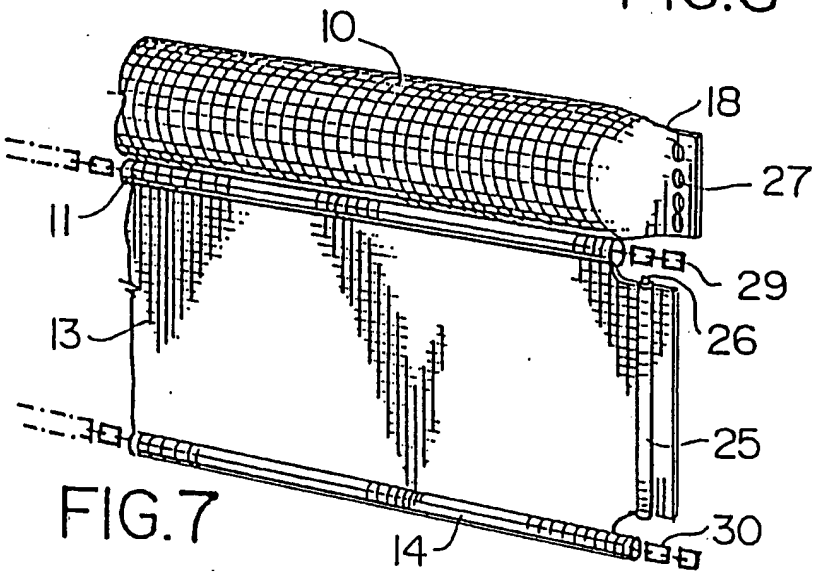


FIG.7

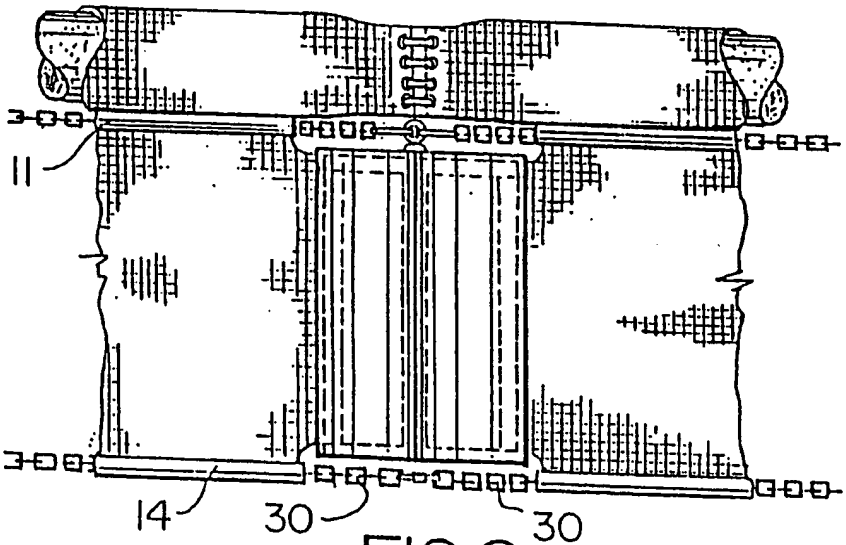


FIG.8

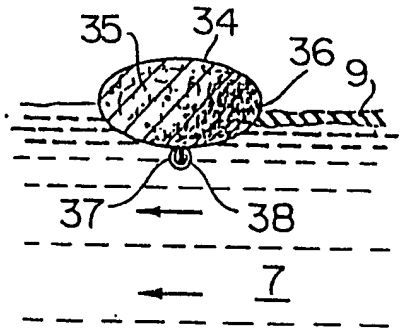


FIG.9

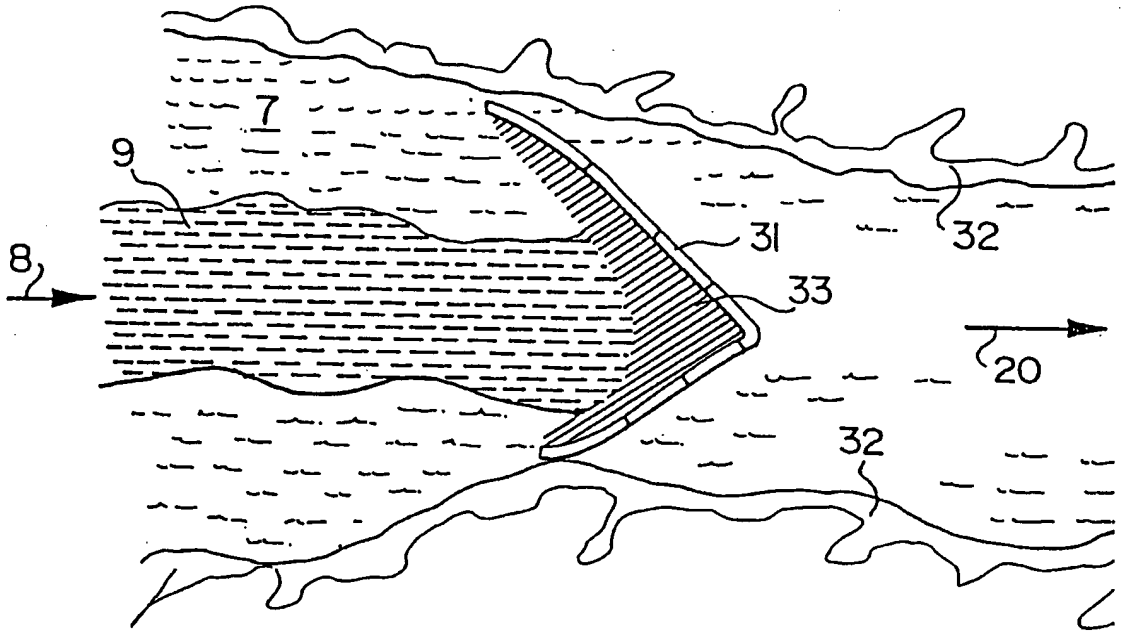


FIG.10